SCIENCE INFORMATION SYSTEMS NEWSLETTER

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Welcome to Issue 45

1997

The NASA Science Information Systems Newsletter (SISN) is prepared for the Office of Space Science (OSS), Science Information Systems (SIS) Program through an agreement with the Jet Propulsion Laboratory. The newsletter, which has been an ongoing task for over ten years, is a forum for the space science and applications research community to report research and development activities, outreach activities, and technology transference. SISN offers a venue for articles that are not likely to appear elsewhere and provides the opportunity for information exchange within the science community, as well as a platform for accomplishments by that community. Related articles from other programs and agencies are also published.

Questions or comments regarding this newsletter task may be emailed to Sandi Beck at <sandi.beck@jpl.nasa.gov>.

Credits: Design and format by Editor, Sandi Beck. Graphics design, animation, and rollovers by Scott Brenneisen, XTREME GRAFX. Also, thanks over the years to Calvin Yee, formerly of Telos Information Systems, Doug Steinwand, formerly of JPL, and the JPL documentation staff.

NASA Computing Technology Featured at SC'97

Five NASA centers hosted a combined exhibit of computing technology at the annual Supercomputing conference, SC97 High Performance Networking and Computing, in San Jose, California, this November. The combined exhibit, one of the largest at the show, is a first for NASA and required extensive coordination over several months from personnel at Ames Research Center (ARC), Goddard Space Flight Center (GSFC), Jet Propulsion Laboratory (JPL), Langley Research Center (LaRC), and Lewis Research Center (LeRC). At the NASA booth, 19 workstations and monitors demonstrated software, hardware, a variety of supercomputing-related work, and the Stereo Visualization Theater (SVT). In addition to the combined-centers exhibit, NASA-related research was featured in the conference technical sessions, with researchers presenting papers and leading workshops.

Larry Hofman of ARC's High Performance Computing and Communications Program (HPCCP) office explained that the biggest challenge of preparing for the conference was to include everything that the centers wanted to showcase. The NASA exhibitors were pleased that the combined booth was one of the more popular exhibits at SC '97.

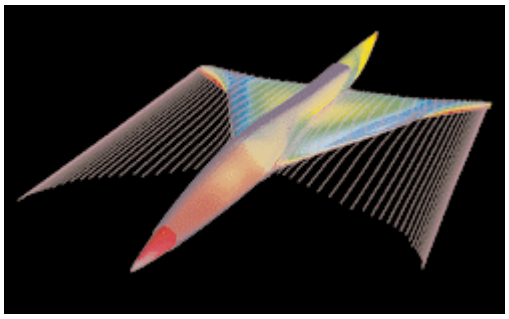
"It has been a great experience working with people at the other centers to bring together all the tremendous high performance networking and computing research that is being done within NASA," Hoffman said.

SC97 was sponsored by the Association for Computing Machinery (ACM) Special Interest Group on Computer Architecture (SIGARCH) and the IEEE Computer Society Technical Committees on Supercomputing Applications and Computer Architecture. The infrastructure for this week-long event was pulled together by a myriad of volunteers who drew on the resources and expertise of the nation's best in communications and support.

NASA theatre

The SVT presentation of a 3D animation highlighting NASA research from all five centers was a feature attraction of the conference. Developed by ARC's Numerical Aerospace Simulation (NAS) Systems Division's multimedia team, the SVT brings together graphics, digital audio, and stereo projection in a presentation system that delivers a degree of resolution not possible with conventional video tape or multimedia. Datasets from several NASA sites featured various areas of research, from aerospace to stratospheric dynamics. ARC's SVT presentation included:

- flow traces through an axial-symmetric CFD analysis of a full-engine simulation. The engine is the "E-cubed" (Energy Efficient Engine) that NASA helped develop in the 1980s. This full-engine simulation demonstrates how all the parts of the engine interact. The simulation is one of many created at the Numerical Propulsion System Simulator at LeRC.
- a 3D rendering of methane in the stratosphere. Data retrieved from the NASA Upper Atmosphere Research Satellite (UARS) was assimilated into a complete gridded dataset using the Kalman filter, developed at NASA's Data Assimilation Office at GSFC. This is one of the first stratospheric datasets formed using Four Dimensional Data Assimilation, which uses the Kalman filter method. It is also one of the first renderings of 3D dynamics in the stratosphere. The most important aspect of the Kalman filter is its ability to form complete datasets for purposes of climate research and visualization from the scattered data from a satellite.
- unsteady visualization of particle streaks in a cavity housing a 2.5 meter (eight feet) aperture Cassegrain telescope in the Stratospheric Observatory For Infrared Astronomy (SOFIA), under development at ARC. This Boeing 747 aircraft will fly in the Earth's stratosphere, at around 13 km (44,000 ft.). Using windtunnel and computational fluid dynamics data, the researchers seek to understand and resolve issues arising from the location of the telescope in an open hole in the aircraft during flight. The simulation solves unsteady Navier-Stokes equations on an overset grid framework using the OVERFLOW flow solver. The visualization uses UFAT, the Unsteady Flow Analysis Toolkit, developed at ARC.
- simulation of airflow around a design for a high-speed civil transport aircraft



Simulation of airflow around a design for a high-speed civil transport aircraft. The wing and body are colored according to the local surface pressure on the vehicle at supersonic cruise conditions. The streamlined nature of this configuration is exhibited by the relatively small disturbances in the particle traces displayed. Simulation of airflow around a design for a high-speed civil transport aircraft. The wing and body are colored according to the local surface pressure on the vehicle at supersonic cruise conditions. The streamlined nature of this configuration is exhibited by the relatively small disturbances in the particle traces displayed.

- simulation of the reaction between two molecules: a benzyne molecule and a carbon nanotube (a hollow tube with one-atom-thick sides). The theoretical molecule created by this simulated reaction has yet to be manufactured, but calculations show that it should be viable. A carefully controlled series of these reactions could make atomically precise gears. The animation showed that when one such gear is forced to turn, interatomic and intermolecular forces cause a second gear to turn. Microscopic gears are a small step toward creating the manufacturing systems of the future, which may revolutionize medicine, materials science, and space travel.
- an introduction to the Information Power Grid (IPG), an initiative to create a nationwide computational capability. The IPG will seamlessly integrate high-performance computing, data storage, and visualization resources around the country into a unified, interdisciplinary, problem-solving environment.

JPL presented both "movies" and interactive demonstrations in the SVT, including: "The Past is Prolog," a review of 20 years of human exploration of Mars culminated by the Pathfinder mission; the real-time manipulation of 3D data sets on a supercomputer at GSFC using the NASA Research and Education Network (NREN) and PARVOC, a parallel visualization tool; and real-time exploration of a 1,500-image synthetic aperture radar scene of the Amazon basin using a "digital light table."

The SVT, intended for high-quality presentation to multiple participants, is useful for peer reviews, scientific visualization presentations, and stereoscopic visualization of scientific data. Through the use of polarized glasses, two different images are displayed on the screen simultaneously, but each eye sees only one of the imagescreating the illusion of depth and three dimensions.

ARC's exhibit

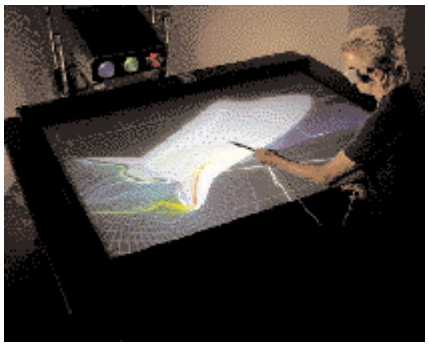
ARC's HPCCP's Learning Technologies Project (LTP), managed out of ARC, involves 10 NASA centers that use emerging technologies to inform the educational community about science. At SC97, LTP demonstrated the use of these emerging technologies and proven approaches, including:

- distance learning through low-bandwidth desktop teleconferencing
- web-based applications for applying remotely sensed data to the classroom
- Digital Library Technologies, including the Alexandria Digital Library, where users can browse library holdings electronically and search by spatial or temporal location or by metadata content
- low-cost networking solutions that allow schools to connect many campuses through a single, standard phone line

The challenge in adapting scientific tools and information to the classroom is that the typical school infrastructure does not currently support the requirements of these applications. However, using emerging technologies and proven approaches such as data compression and data streaming to overcome bandwidth limitations, LTP provides a workable model for the classroom.

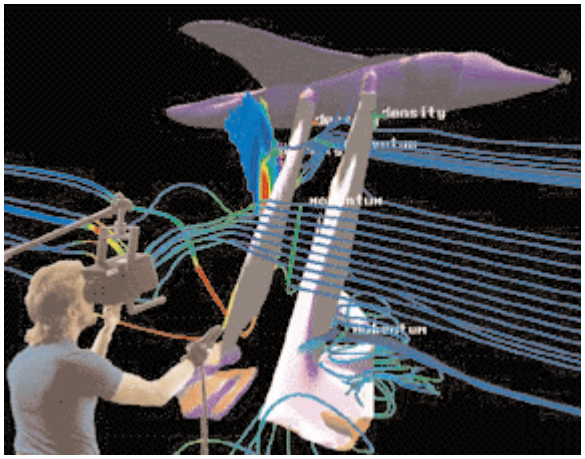
An experimental network, featuring guaranteed quality-of-service for high-performance networks, connected the show floor to three supercomputing applications: the Development Aeronautics Revolutionizing Wind tunnels and Intelligent systems for NASA (DARWIN) and Surface Movement Advisor (SMA) projects at ARC and a virtual studio environment at Paramount studios in Hollywood, California. The network connected the San Jose Convention Center to DARWIN facilities throughout ARC, providing access to DARWIN windtunnel and computational datasets. To show SMA, the network connected to the control towers at Moffett Field, San Francisco Airport, and the Atlanta Hartsfield Airport, to provide real-time updates of weather conditions, ground control, and flight status at each airport. To demonstrate the virtual studio for Hollywood, the network combined high-performance video sources, editing, and displays on the show floor. The virtual studio demonstrated how networks and network QOS can be used to enable real-time distance-independent video production, using content developed on the show floor combined with video from Hollywood and NASA.

One of ARC's featured attractions was the "Immersive Workbench." a real-time stereographic, virtual-reality demonstration of three datasets: surface flow visualization and automatic flow feature detection - both from computational fluid dynamics simulations, and a "virtual wind tunnel" (VWT) and Mouse-based VWT.



The Immersive Workbench

The VWT is currently being used on a trial basis at Boeing Computer Services, Rockwell Science Center, and LaRC. The demo showed interactive streamlines of airflow around an aircraft generated using the VWT. Mouse-based VWT is software that applies virtual reality interface technology to the visualization of precomputed computational fluid dynamics simulations. Mouse-based VWT brings most of the intuitive three-dimensional interaction capabilities of the VWT to those with SGI workstations. The Workbench also demonstrated exVis and Visual Integration of Simulated and Observed Results (VISOR), two software packages that are Multi-Source Visualization project tools used to support the display and analysis.



The VWT is a three-dimensional display that gives the user superior perception of the complicated structures that arise in fluid flow. Interactive visualization techniques allow intuitive and rapid exploration of flow phenomena, providing rapid understanding of complex flows.

The Automatic Flow Feature Detection software showcased on the Immersive Workbench features detection algorithms being developed that automatically analyze gigabyte datasets and extract important flow features, such as vortex cores and separation lines. This software was developed in response to NASA's industrial partners, who requested tools that would reduce the analysis time of large computational fluid dynamics simulations. The demonstration showed vortex cores, separation and re-attachment lines, and surface "oil" flow patterns that were extracted from a 10-gigabyte dataset, without human intervention.

An actual implementation of the virtual laboratory, VLAB, was demonstrated via a real-time connection to the vertical motion simulator (VMS) facility at ARC, supplied by the NREN. Visitors were able to interact with ongoing flight simulations at the VMS.

VLAB, a project to develop the technology and methodology for remote access to a research facility, employs an interactive, multi-user, virtual reality interface.

Although VLAB's first application is in flight simulation, the concepts being developed for applicability to any remote-access, virtual-control-room situation, such as wind tunnels, flight test facilities, and multiple, interoperable labs. The emphasis is on the user's perspective of a virtual environment in which the user interactively defines the specific data and display configuration that will afford the most productive participation in the experiment. VLAB also allows managers to participate in demonstrations from diverse functional areas such as program planning, flight operations, and system design, indicating that the VLAB concept could "play" in Integrated Design System, remote flight test, and in a myriad of other programs.

Several software packages developed by ARC's Numerical Analysis Simulation (NAS) systems division were demonstrated at the conference, such as:

- AIMS, a software toolkit developed at ARC over the past six years, allows users to tune their parallel programs by revealing execution bottlenecks. Its easy-to-use graphical interface enables performance data to be collected and analyzed automatically. The Department of Commerce recently allowed worldwide distribution of AIMS, without restriction or copyright. The SC97 demonstration highlighted basic features of AIMS, including a new feature utilizing statistics to shorten trace files.
- the NTV, a tool used to visualize execution traces from message-passing systems, is designed to be ported easily to different trace formats, and supports traces produced on the IBM SP2 using the native IBM Message Passing Interface trace, as well as trace files produced using AIMS. A distinctive characteristic of NTV is that it uses static displays rather than time-varying displays. This, in combination with mouse-controlled zooming, gives users the ability to see a global view of the execution and a focused view of details. The principal display is a time-line that is color coded to show status for each processor. Two types of summary (profiling) displays are also produced. One allocates information by processor (for example, the time the processor was blocked sending), the other allocates information by function (for example, the time a function was blocked sending).
- the Portable Parallel/Distributed Debugger (p2d2), is a debugging system for parallel and distributed programs that was developed for the dual purposes of providing a consistent user interface across all platforms (reducing the amount of effort required to learn how to use a debugger) and providing user interface features that scale to a large number of processes. A recent update allows the debugger to support breakpoints inserted in a timeline, and makes it possible to have an "undo" operation. The demonstration showed how execution trace information can be used to understand what has happened during the course of a computation. The demo also highlighted p2d2's basic capabilities, its accommodation for multidisciplinary codes, and the power of its scalable user interface.
- the Unsteady Flow Line Integral Convolution (UFLIC), a software package that supports flow visualization of CFD aerodynamic simulations, featured interactive surface flow visualization applied to several aircraft, ani-

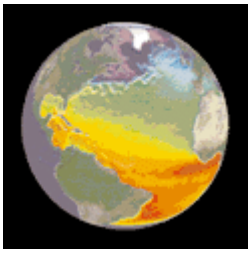
mation of surface flow patterns from time-dependent flow fields, and automatic flow feature detections from the surface flow patterns.

- the Portable Message-Passing I/O library (PMPIO) is a parallel I/O library based on a subset of the I/O chapter of the recently completed MPI-2 standard. PMPIO is one of the first implementations of a standard parallel I/O library. With a standard message-passing and I/O library, it is now possible to create complete applications that are portable across most parallel systems. PMPIO also provides improved performance for scientific applications that utilize complex data layouts through a specialized buffering technique. PMPIO completes the infrastructure for developing portable, high-performance parallel applications by providing an open standard I/O interface. Target applications are scientific parallel codes based on the MPI message-passing standard. PMPIO runs on most parallel systems that can run the MPICH MPI library, developed by Argonne National Laboratory and Mississippi State University. Examples include the IBM SP2 and the Intel Paragon, as well as IBM, Silicon Graphics Inc., and Sun Microsystems workstation clusters.
- exVis, a Multi-Source Visualization project tool used on the Immersive Workbench. exVis is designed to support visualization and analysis of data collected with unusual instruments during wind tunnel experiments. The common element in this data is that it is acquired using image-based systems. exVis allows two-dimensional display and interactive query of the data. The software allows display with user-controlled color mappings and includes a tool for selecting a subset of data to plot in the form experimental researchers are familiar with. exVis is available through the NAS Software Archive.
- VISOR, yet another Multi-Source Visualization project tool used on the Immersive Workbench. VISOR is a program designed to display data selected from several sources (computational and experimental) in a single three-dimensional environment. In this way, data acquired in separate tests, from different types of sensors or simulation results, can be displayed together to allow comparisons and improve understanding. This demo will show a pre-release version of VISOR.

NAS also showcased a new architectural prototype, called "Whitney," built entirely from commodity personal computer hardware components to help researchers design extremely scalable systems software for future petaflop-class systems. The main goals of this prototype are to allow design of extremely scalable systems software, investigation of cost-effective supercomputing, and evaluation of commodity components. Designed to support a traditional supercomputer workload (many users, many jobs), Whitney will provide a testbed for scalable systems software and will initially be used both as a computing platform and as a testbed to study various cost/performance tradeoffs in larger systems.

Whitney

GSFC's exhibit



Goddard presented a videotape, "Images of Earth and Space: SC97 Edition." featuring current computational research in the fields of Earth and space science.Viewers were taken on an electronic voyage through the solar system and outer space, from complex simulation models of the Earth's oceans and climate, to the Sun's corona, to inter-galactic collisions.

In the video, scientific visualizations from GSFC, JPL, and the HPCC Earth and Space Sciences Project are depicted in graphical form. First stop is the Sun's interior to study turbulent processes that fuel observed solar activity. A long layover on Earth begins with an expedition over solid surface and through the underlying theory for mantle. Next, the warm waters of the 1997 El Nino invade the Eastern Pacific, while narrow currents flow through the Northern Atlantic. Ocean life worldwide is then traced with the latest satellite data. Jumping to the atmosphere, spectators attend a hurricane parade above the Atlantic and watch the waves and spirals of methane around the globe. A jaunt to Mars explores the mountains and trenches of its dry, rocky exterior. The journey concludes at a binary neutron star system, where two city-sized objects with the Sun's mass merge in a titanic explosion.

JPL's exhibit

JPL demonstrated the Microwave Optics Design (MOD) Tool, an integration of existing microwave and optics analysis software with a solid computer aided design (CAD) modeler and structural and thermal tools. Many of JPL's NASA missions use a microwave optics instrument to gather scientific data. The high-performance computing group, in cooperation with the MIRO project, is using distributed and high-performance computing to reduce the amount of time needed to design and analyze such instruments. Many independent software packages are used in this design and analysis process, but JPL is in the process of integrating a number of these packages into a distributed environment, porting some

of them to high-performance, parallel platforms. Other JPL workstation demonstrations included parallel extensions to MATLAB, a high performance mathematical tool environment; a parallel-adaptive mesh refinement system; and object-oriented FORTRAN 90.

The MOD Tool integrates existing microwave and optics analysis software with a solid CAD modeler and structural and thermal tools, with the goals of speeding up the development process for new instruments and improving the final instruments by allowing more design iterations.

LaRC's exhibit

LaRC and ARC demonstrated the NASA Metacenter, a joint exploratory project between their parallel systems groups. This fall, the Metacenter expanded to also include LeRC. The focus of the project is to achieve more effective use of NASA supercomputers by making the systems more easily available to researchers, and by providing quicker turnaround for batch jobs, a larger range of available resources for computation, and a better distribution of the computational workload across multiple supercomputers.

The "glue" that combines supercomputers at widely separated locations into one "Metacenter" is the ARC-developed job management software called Portable Batch System (PBS). The designers of PBS recognized that the job scheduler is the most site-specific part of a batch queuing system, because the scheduler implements local policy. Writing a "peer-scheduler" as the external scheduler enables jobs to run on any system in the Metacenter. In addition, a significant amount of administration has been streamlined, including account maintenance, system and job accounting, and project allocations.

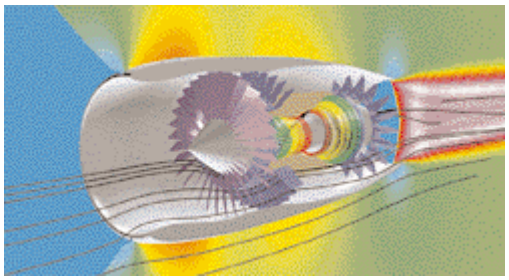
LaRC also demonstrated its Framework for Interdisciplinary Design Optimization (FIDO), a software system that allows interdisciplinary coupling between computational fluid dynamics and finite element structural analysis codes. Simultaneous computer optimization of design elements across multiple disciplines will allow significant time and cost reductions in aircraft design processes. A video presentation showed how FIDO uses parallel and distributed computing to enable timely execution of complex codes, and simultaneous calculation of many interdisciplinary sensitivities. The demonstration showed how the system distributes the design process over a network of computers, controlling the entire process by advanced optimization methods. Additional research will allow visualization of various analyses conducted during the design process. Examples of these visualization methods are shown in an impressive gallery of images generated by the Parallel Graphics Library, developed at LaRC's Institute for Computer Applications in Science and Engineering.

LeRC's exhibit

LeRC demonstrated the use of an Intel Pentium Pro (P6) cluster for running compute-intensive computational fluid dynamics applications at significantly reduced cost, compared to more traditional platforms such as UNIX workstations and massively parallel machines. The P6 cluster consists of sixteen 200-megahertz Intel Pentium Pro processors.

The CORSAIR combustion code was selected as a representative application for presentation at SC97. CORSAIR is a Navier-Stokes flow solver based on an explicit four-stage Runge-Kutta scheme, using unstructured meshes. CORSAIR, normally run on networked workstations, was ported to the P6 cluster under both the Windows NT and Linux environments.

The code was run under the Linux environment with a standard test case that has approximately 116,000 computational elements. The performance results of the reacting flow test case were compared to results achieved with the same test case on the HPCC Program's IBM SP2. The results from both systems were nearly identical, demonstrating that the 16-node P6 platform yields good performance at a significantly lower cost, and that it can be a viable platform for medium-scale applications.



LeRC uses state-of-the-art computational fluid dynamics techniques like the axisymmetric, aerodynamic, full-engine simulation ENG20, which can simulate and visualize a complete jet engine.

The code is designed to incorporate an aircraft-engine company's component codes, and include their results in the engine simulation. In this way, a component or system designer can simulate the result of a component design change on the entire engine system. These techniques will be used to make aircraft engines quieter, more affordable, and more environmentally friendly. LeRC presented the results from ENG20, in correlation with the video, "The Numerical Propulsion System Simulation: A New World of Aircraft Engine Design," available for viewing in the SVT. The video emphasizes the Numerical Propulsion System Simulator (NPSS) program's direct and indirect benefits to US taxpayers, including reduction in the time and cost of designing and building aircraft engines, making US engine companies more competitive in the world market. The video highlights the work done at NPSS and shows some of the program's high-performance computing and communications technology, visualization tools, and aerodynamical computational tools.

LeRC's space communications group demonstrated extremely high data-rate transmission over NASA's Advanced Communications Technology Satellite (ACTS). A terabyte data set was exchanged between Cleveland, Ohio, and the show floor using high-speed tape robots. In addition, LeRC researchers demonstrated Engine Simulator 2.0 software (ENG20), which can simulate and visualize a complete jet engine.

LeRC's Space Communications group is sponsoring high data-rate demonstrations, which link the SC97 show floor to Cleveland, OH using their Advanced Communications Technology Satellite (ACTS). This experiment will employ a 622-megabit networking path to exchange data across the country, using a combination of terrestrial-and ground-based network links. This geographically distributed experimental network will showcase applications requiring high bandwidth communications between distant locations.

ACTS provides for the development and flight test of high-risk, advanced communications satellite technology. Using advanced antenna beams and on-board switching and processing systems, ACTS is pioneering new initiatives in communications satellite technology.

About SC97

In addition to the research exhibit venue, of which NASA was a large participant (as outlined above), SC97 offered 17 tutorials, a technical track, a series of town hall meetings, an education program, and a History of the Internet. This year's research exhibition was the largest in the history of the SC conference series, and featured industry exhibits as well as non-commercial research. Tutorials covered a wide range of topics, including do-it-yourself supercomputers, MPI, parallel adaptive mesh refinement solutions, data mining, performance evaluation, metacomputing systems, and Java. The technical track was comprised of all aspects of high performance networking and computing. The education program focused on the role of technology in lifelong learning where new models for teaching and learning making use of emerging computing technologies were explored. LeRC participated in the Education Program with a presentation of the Lewis Learning Technologies, part of NASA's Learning Technology Project.

Material reprinted from NAS News, Nov-Dec issue, SC97 Special Section, from the SC97 Web site, and from contributions by Jarrett Cohen, Science Writer, Goddard Space Flight Center. ■

AISRP 1997 Investigator Workshop Report

The Applied Information Systems Research Program (AISRP) hosted an Investigator Workshop at Goddard Space Flight Center (GSFC) last September. Al Diaz, deputy director at GSFC welcomed the investigators and Joe Bredekamp, NASA official in charge of the AISR Program, kicked off the two day event. The workshop forum included panel discussions, breakout groups, research demonstrations, and paper and poster presentations.

Day one

Eric Smith, presented a paper on the "Next Generation Space Telescope." Principal Investigator (PI) Sessions I and II focused on data analysis and visualization followed by a panel discussion on related technology activities; for example, high performance computing and communication, autonomy, and information management. The Space Science Data System Technical Working Group then met. Day one finished up with informal demonstrations and poster sessions.

Day two

Steve Curtis presented a paper on "Solar Terrestrial Probes Program." PI Session III focused on information management. The afternoon program included additional demonstrations and poster sessions. The two day workshop concluded with a "Birds of Feather" sessions on program administration; reporting, grants renewal process; and "visibility and presence", then the "Wrap-up and Parting Shots."

Note: Future newsletter issues will publish papers presented at the 1997 Investigator Workshop.

About AISRP

The AISR program maintains an awareness of emerging technologies applicable to space science disciplines, supports applied research in computer and information systems science and technology to enhance NASA Office of Space Science (OSS) programs, stimulates application development where warranted, and provides for the systems analysis and engineering required to transfer new technology into evolving OSS space science programs through NASA Research Announcements (NRAs). Specific areas of interest include:

- High Performance Computing and Networking
- Scientific Data Analysis and Visualization
- Scientific Data Storage and Management
- Software Technology, including World Wide Web tools

Learn more about AISRP at <http://www.hq.nasa.gov/office/oss/computer/aisr/aisrp.html>.■

LightSAR Revelations Promising For Both Science and Industry

Diane F. Miller, Science Writer, Jet Propulsion Laboratory

LightSAR is a low-cost, Earth-orbiting, imaging radar satellite proposed as part of NASA's Mission to Planet Earth program. It will use advanced technologies to reduce the cost and enhance the quality of radar-based information for scientific research, commercial remote sensing, and emergency management applications. LightSAR is planned to orbit for three to five years, providing all-weather, day-night measurements of most locations on Earth about once each day.

Because LightSAR offers important benefits to both the science community and US industry, an innovative government-industry teaming approach is being explored, with industry sharing the cost of developing LightSAR in return for commercial rights to its data. Jet Propulsion Laboratory (JPL) is leading the development of LightSAR for NASA, in collaboration with Stennis Space Center and four industry teams.

In November 1997, four independent industry studies reported their findings on innovative approaches to government-industry teaming, and concepts for maximizing commercial investiment in LightSAR. Information from their eight month studies covered a wide range of technical and business analysis. Results from their studies concluded that LightSAR has the potential to produce important science results while opening new markets and creating lucrative long-term sustainable businesses. All the industry teams recommended that NASA move forward with LightSAR, and they are prepared to participate and invest in the next phases of a LightSAR government-industry partnership. NASA is currently developing a LightSAR program plan based upon these inputs.

A technological jump

The LightSAR satellite would be the most sophisticated and capable radar system in orbit today, providing nearly complete coverage of the Earth's surface every 8-10 days. LightSAR could provide calibrated measurements of most locations on Earth about once each day. This repeating coverage would give LightSAR the unique capability to continuously monitor changes in the Earth's topography as small as a few millimeters. Capabilities under study would enable the radar to measure features as small as 1-3 meters, offering significant potential for commercial use in topographic mapping, land management, planning, and development.

The information from LightSAR could potentially be used to address a whole range of practical issues, including:

- measuring ground surface displacement, to provide insight into earthquakes and volcanoes and support emergency management efforts
- studying the movements and changing size of glaciers and ice floes to help better understand long-term climate variability
- developing highly detailed and accurate elevation maps
- monitoring floods and where they are likely to occur
- assessing terrain for the likelihood of finding oil or other natural resources
- recognizing oil spills early and then monitoring them
- assessing the health of crops and forests
- planning urban development and likely effects
- studying land cover and land use change

Using the data

One example of Lightsar data usage is in the study of earthquakes. Seismologists are now studying radar images that clearly show surface displacements caused by ground motion at earthquake sites. These displacements can be measured accurately to within a fraction of a centimeter. By monitoring a fault zone after it has experienced an earthquake, scientists may be able to determine whether subsequent earthquakes and aftershocks are adding to or relieving stress. Continuous imaging would allow scientists to pinpoint areas where stress is building, making these areas at risk for future quakes. LightSAR will provide this continuous imaging. In addition, LightSAR will provide higher resolution images, with a millimeter-level surface displacement resolution. This improved resolution will allow very precise monitoring of Earth movements.

Over the past two decades, space geodetic techniques, in particular, the Global Positioning Satellite (GPS) system, have proven powerful in studying movements and deformations of the Earth's surface, leading to major advances in our ability to quantitatively model these effects. But these measurements lack spatial continuity and require field equipment at each study site. Recent technological advances in spaceborne radar interferometry permit observation of mm-level surface deformation at 25-m resolution all over the globe. Derivation of the first differential interferometric maps of the co-seismic displacement of the June 28, 1992, Landers quake was arguably the most exciting recent result in earthquake geodesy. Nevertheless, at present, civilian spaceborne differential interferometry remains primarily a demonstration tool, because no mission dedicated to that purpose exists. Thus, one of the high-priority scientific goals of LightSAR is to

refine our understanding of the earthquake cycle through mm-level interseismic and co-seismic vector deformation maps along faults and plate boundaries.

LightSAR will allow the repeated measurement of surface change in seismically active areas along all continental margins and will be able to target new and previously unidentified areas of study. It will be able to image any particular area every eight days, or all areas every 24 days.

Another high-priority scientific goal of LightSAR is to gather data for mm-level deformation maps to monitor volcanoes for new activity and the potential for imminent eruption. The major observations in volcanology to be obtained by LightSAR are:

- the spatial and temporal extent of deformation preceding and accompanying eruptions, which are key observables constraining models of magma migration
- the spatial extent of new material produced during an eruption, derived from image decorrelation, an important diagnostic of the eruption process

Surface change caused either by the emplacement of new lava flows or by the collapse of volcanic craters, can be studied via the decorrelation of radar phase information at a spatial resolution of ~25 m/pixel. Specific high priority volcanoes (for example, those in eruption or experiencing a "volcanic crisis" prior to eruption) may be imaged every orbit, while other areas can be imaged as few as four times per year.

This comparison shows photographic and radar images of the Kliuchevskoi volcano in Kamchatka, Russia, which began to erupt on September 30, 1994, as the second SIR-C/X-SAR space shuttle mission was beginning.

Another important use of LightSAR data is in monitoring the global carbon cycle. The carbon cycle, especially as it affects concentrations of carbon dioxide and its role as a greenhouse gas, is fundamental to the study of Earth's climate. Carbon is stored in the form of plant material. Biomass is the weight of plant material, minus the water it contains, per a given area of land.

The seasonal growth of terrestrial plants, and forests in particular, leads to the temporary storage of large amounts of carbon, which could directly affect changes in global climate. In order to accurately predict future global change, scientists need detailed information about current distribution of vegetation types and the amount of biomass present around the globe. Optical techniques to determine net biomass don't work very well if the area being imaged is often covered by clouds. Imaging radar, however, can penetrate through cloud-cover with hardly any loss of information. Among remote sensing instruments, radar has been shown to have the unique abilities to respond to biomass over a usable range and give reliable temporal information, because it sees through cloud cover. For an L-band radar, biomass values of up to 150-200 tons/hectare have been successfully retrieved.

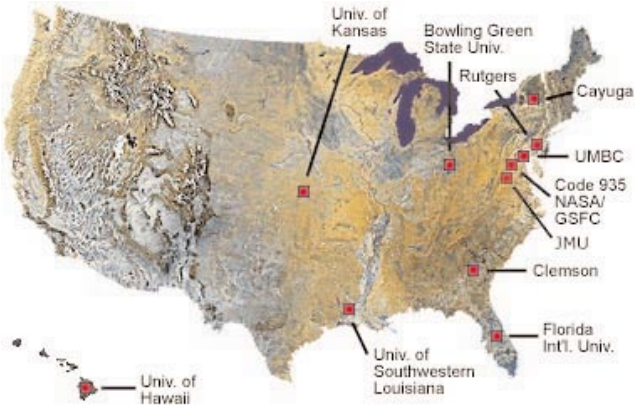
Change in land cover is one of the fundamental factors perturbing the global carbon cycle. In addition to identifying primary land conversion, successful efforts are under way using SAR to estimate regrowth in secondary forests, a key factor in carbon balances. LightSAR's use of the longer L-band wavelength will enable monitoring of patterns of forest regrowth after disturbances such as fires or clear cutting. LightSAR is designed to meet the requirements for image resolution so that the boundaries between growth and no-growth areas can be accurately distinguished and mass per unit area can be accurately assessed.

Other potential applications of LightSAR data are described on LightSAR home page at <http://lightsar.jpl.nasa.gov/>. ■

NASA's Regional Application Centers -

Applying Information Technologies to Facilitate Information Access and Regional Development

William Campbell, Jerry Garegnani, Bob Cromp, and Patrick Coronado, Applied Information Sciences Branch, Goddard Space Flight Center, and Paul Clemens, Global Science and Technology, Inc., Maryland



A major barrier to the wider use of Earth remote sensing data is timely access to satellite data products that can be combined easily with other resource management applications already in use by the general user community. The Regional Application Centers (RAC) Program was initiated by Goddard Space Flight Center's (GSFC) Applied Information Sciences Branch (AISB) to extend the benefits of its information technology research and cost-effec tive system development to a broader user community. Based on technologies developed in the AISB over the past several years, the RAC offers a capability to directly receive and manipulate localized satellite data effectively, inexpensively, and on a routine basis.

RAC objectives

The RAC Program resulted from an active interest in making NASA-developed technolo gies available to the general public. The RAC was selected as a means to transfer these technologies to NASA missions and to the outside community. The transfer, in effect, is being accomplished by merging AISB's innovations into a functional system, the RVC, and placing prototype RACs in university locations for testing and validation of data and tech nology.

RAC objectives are based on an overall goal of fostering the self supporting use of environ mental and Earth resource data by regional institutions including state and local government, universities, consortia, and commercial companies. These objectives include:

- promoting the establishment of self-sustaining public and private sector working relationships to broaden user access to NASA data
- refining and transferring NASA technology through collaborative testbedding
- using RAC-created, in situ, and ancillary databases to support the calibration and validation of NASA satellite data
- incorporating RAC applied research results into shareable global environmental knowledge bases
- stimulating the development of associated commercial activities

The RAC Program expects the collaborative development of RAC's with hosting institu tions to meet these objectives. The RAC host organizations gain an inexpensive and flexible capability to acquire, process, archive, locate, access, and use Earth science data for practical applications. NASA obtains feedback on the application of its technologies in real -world, regional scale applications and validation information in the form of multi-temporal datasets of satellite imagery from a widely distributed set of receiving sites.

Promote public access to NASA data

Implementation of RVC information and system technologies is expected to promote more general public utilization of data from the new commercial remote sensing and Mission to Planet Earth (MTPE) satellites by giving the users direct access to the data. By involving the broader user community, the relevancy of science results will be enhanced and the value of the data to regional applications increased.

Collaborate to refine technology

The development of RVC capabilities and applications in collaboration with user organiza tions is intended to both increase the usefulness of MTPE data and the utility of the appli cations. RVCs will foster the creation of new and innovative applications and information products to meet the needs of specific markets or user communities, leading to

gains in Earth resource management, economic growth, and overall quality of life.

The involvement of organizations outside of NASA and the private sector is expected to expedite social and economic benefits to be derived from the application of MTPE data. The collaborative development of systems and processes will make Earth science data easier to preserve, locate, access, and use for practical regional applications.

Validate MTPE data

By virtue of their capability to directly acquire these data under local or regional condi tions, RVCs are expected to serve as a means to validate the data products from the new MTPE and commercial remote sensing satellites. Since validation sites require long-term monitoring where there is in situ expertise and infrastructure to facilitate research, the RVCs are good candidates for this role. The RVC sites represent a wide range of land cover types that can be well characterized on the ground and their observation programs will be of interest to the international global change research community.

Enable data fusion -

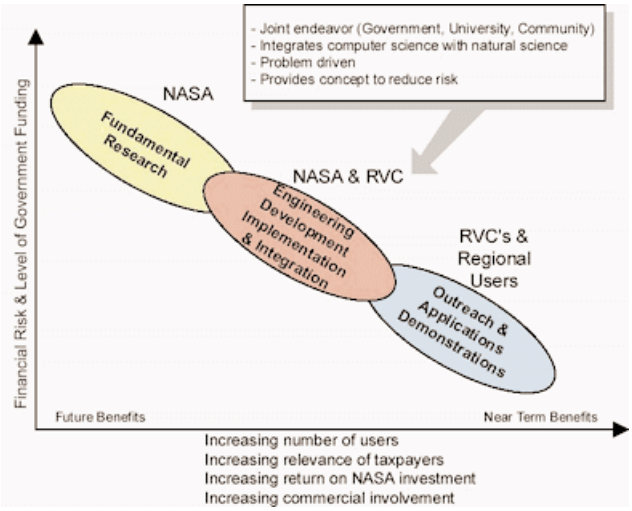


Figure 1. RAC Development Approach

The RAC's capability to fuse, integrate, and assimilate data from satellite sources with other data promises to provide an important capability to the Federal agencies, state and local governments, and private sector users who use geographic information systems and other technologies that benefit from multiple sources of data. Data from diverse sources can be processed into analysis products and presented to users in a form that clarifies the information contained in the data. As a result, the user quickly comprehends the nature of the problem or issue and can develop an effective course of action based on this insight.

Stimulate related commercial activity

The development of RVC technologies and the placement of RVCs in host organizations are intended to stimulate collateral development in the commercial sector. Commercial devel opment is expected in the areas of data processing services, the creation of special analysis products and custom image/data products as well as the development of hardware and software tools to support the exploitation of the data. Such commercial development en hances the relevance of NASA's scientific activity and cost-effectively extends the social and economic benefits of NASA research to a broader user community. See Figure 1 for a graphical representation of this process.

Benefits of the concept

A key advantage of the RAC concept is that it provides the means for data to be converted to useful information and ultimately to the understanding needed to support the decision making process. A secondary benefit is that it enables the cultivation of new commercial enterprises that support regional development, e.g., regional planning studies, economic and demographic studies, agriculture and land-use inventory evaluations, and regional infrastructure assessments.

The RAC's advanced information management technologies provide ready access to the information needed to address regional issues and support regional development. Potential users include governmental organizations, health, and educational institutions as well as private industry. The primary benefit of the RAC for such users is that, for whatever pur pose, they have ready access to data, information, value-added services, and analysis products that are tailored to satisfy their specific requirements.

Benefits accrue to NASA, the host organizations, and the general public. NASA extends the utility of its data, science programs benefit from ground validation data, and GSFC gets to test new processing systems and software for application in other programs. The RVC hosting organizations obtain direct access to satellite data, a low cost, effective data man agement system, and a collaborative relationship with the global research community. Additionally, the RVCs serve as platforms for computer science investigations, automatic data sharing, data and model validation, image mining, heuristic querying, data distribu tion, and the evolution of self-organizing, scientific data management systems.

The general public benefits from the data management capabilities made available to man dated missions of state and local governments (e.g., resource management, disaster relief, education, etc.) as well as from the analysis products offered to commercial profit-making activities (e.g., agribusiness, insurance, weather forecasting, oil exploration, etc.) More generally, these systems will help educate the public about the usefulness of Earth sensing and meteorological satellite data.

Collaboration among RACs

A fundamental objective of the RVC concept is to encourage the collaboration of users and investigators to combine measurements, fuse data, share analysis results, and exchange application software and technologies. By taking advantage of emerging information tech nologies and communication tools, RVC facilities enable disparate communi-

ties of science researchers to join together to solve complex problems.

RAC installations are encouraged to collaborate in three ways: 1) the development of the technologies that support information management, 2) the development of data center applications, and 3) sharing the knowledge gained from analysis supported by the RACs.

Information technologies developed during the program by GSFC or an RAC will be shared with all collaborating RACs to refine access to information products, expand their immediate relevancy, and extend their beneficial use and application.

The RAC design incorporates a listserver to enable and encourage collaboration between RAC facilities. Each of the collaborating RACs is encouraged to establish a site on the World Wide Web as well to aid the exchange of information and provide access to data and infor mation. In addition, SuiteSpot, a Netscape collaboration tool, is installed at all RACs to facilitate communications, data access, and information sharing over the Internet.

Establishing a RAC

The AISB at GSFC is willing to collaborate with other institutions to help establish an RAC or some subset of RAC capabilities at those institutions' facilities. Such collaboration re quires that a Memorandum of Agreement be written between NASA and the institution to identify responsibilities and establish a working relationship.

Basic to the collaboration is a context of testing and demonstration in which both NASA and the local institution jointly contribute toward developing an information system to meet the needs of the host region. Typically, NASA will provide copies of the advanced information management software being developed for the RVCs. The collaborating insti tutions will typically establish an RAC facility and tailor the technologies provided by NASA to meet regional user needs. Since no monies are exchanged, each institution is expected to provide its own facility and/or infrastructure and the operating costs of the RAC are borne by the host institution.

The information system technologies provided as NASA's contribution to such RACs are being developed using a "testbed engineering" approach. Under this approach, NASA provides the collaborating RACs with an initial information management capability and the RACs in turn develop applications to meet their individual goals and operations scenarios. Initially, each RAC is expected to have access to a direct readout Earthstation or other source of satellite data. However, with the advent of data sharing federations, such a direct data-receive capability may not be required.

In order to participate in the program, each RAC will have to develop scenarios describing what they want to accomplish and come to an agreement with GSFC's AISB upon a way of testing and demonstrating these scenarios in the RAC. Upon installation of the RAC hard ware and information system software, and after the appropriate demonstrations, the RACs will begin their respective missions. New applications required by the RVC missions will be developed as part of the collaboration with AISB. Although the RACs have primary responsibility for creating new functions or applications within their domains, the govern ment will participate at its discretion and contingent upon budget constraints. Priority will be given to those functions that require information technology research and are applicable to all the RACs.

RAC development history

RAC systems evolved from two technological initiatives of the AISB: the Satellite Direct Readout project and the Intelligent Information Fusion project. The Satellite Direct Readout project entailed the development and installation of a number of ground stations world wide. Among these are three stations in Russia supporting forest monitoring and fire detec tion, stations in Thailand and Bangladesh supporting tropical storm warning and flood forecasting, a station in Mongolia for rangeland monitoring, and stations in Guam and Fiji for typhoon warning. The satellite real-time data streams captured by these stations include the Geostationary Operational Evironmental Satellite, Television Infrared Observing Satellite, the Geostationary Meteorological Satellite, and the Defense Meteorological Satellite Program. The Intelligent Information Fusion project encompassed the development of an end-to-end scientific spatial database management system to incor porate and evaluate advanced techniques for handling current and future NASA scientific data management challenges.

The RAC concept is derived from, and combines, a number of technological innovations developed in AISB over the past few years. One set of innovations deals with technologies related to gathering, processing, storing, and retrieving data in massive distributed data bases, including database design and management. A second set deals with the use of state -of-the-art electronic capabilities to facilitate the management of organizational processes. A third area is that of data analysis and visualization to ensure maximum return on our nation's science investment.

AISB's information systems efforts have focused on designing and building digital libraries to provide highly intelligent search, selection, and access services to the general public over high-speed digital communication network services. Technologies being developed include:

- seamless access systems, which require no user understanding of a library's organization, information access, or data content
- data mining; automated data search
- data viewing and real-time data browse
- hypothesis-based systems that respond to requests confirming evidence for pattern causation leading to suspected events
- peer-grouped requests identifying similarities between users, for information and goal sharing
- information and data dispersal management across geographically-distributed, independent libraries
- representation and manipulation of multi-dimensional data

- automatic data retrieval based on content

As part of the overall effort, integrated families of system utilities, visualization tools, and analysis algorithms are being developed to enable the interactive manipulation of large, complex multi-dimensional datasets residing at remote locations. The ultimate goal is to create a scientific computing environment that allows the user to access raw data to gener ate derived products and extract scientific information easily and quickly. The target envi ronment requires visually based data representation and user interaction, a high-level of network communication, and concurrent and/or parallel processing on a wide variety of platforms.

RAC design

The RAC integrates advanced information management technologies throughout the data system to efficiently manage all functional aspects of the system as well as to extract, collect, and intelligently store the information contained in the data for later access. Both input data requirements (source, data type, rate, volume, and characterization) and user application requirements (data product generation, meteorological analysis, interactive query, and data access/display) are accommodated by the RAC concept. The RAC system provides:

- software that accurately maps satellite data to the regional geography for use in agriculture, forestry, environmental studies, weather prediction, etc
- automated analysis programs that extract content-based information from multifaceted data archives and generate user-specified knowledge products
- intelligent information management routines that automatically select and execute system functions for product generation and distribution
- spatial indexes, detailed metadata (information about the data), and intuitive graphical interfaces that help users select data from a multitude of data types and remote sensing data sources

Technical features

Integrated Data Acquisition and Information System Capabilities

A key feature of the RAC technical approach is the thorough integration of satellite direct readout capabilities with information management functions. Rather than acquiring and storing data for later off-line processing and product generation, a single intelligent data management function controls all data acquisition, processing, storage, and access opera tions throughout the system. In addition to providing data and information quickly and efficiently, this approach ensures the long-term value of the information products and greatly increases the user's chances of finding relevant information in the enormous vol umes of data captured by the system.

Data fusion

A key characteristic of the RAC is its capability to fuse or combine data from multiple sources to create new products. Satellite imagery, for example, can be fused with data from various other sources (economic, geographic, demographic) to generate information prod ucts to meet the requirements of public and private clients. The fusion of data from mul tiple sources is accomplished by relating each picture element or observation data point to its specific location on Earth. For image files, bilinear interpolation on a grid is used to produce latitude/longitude information for every pixel and the inverse function. Since all data in the system has this information, arbitrary cartographic projections can be applied to single images, or to groups of images, allowing them to be displayed simultaneously. Visualization techniques vary, and depend on the data being fused, but the navigation grid provides the baseline necessary to perform the function.

Automatic data characterization and cataloging

A data characterization and cataloging feature monitors the incoming data stream during processing to automatically determine data content features and add that information to the database along with typical acquisition-related metadata. This feature takes full advan tage of the integration of direct readout and data fusion to facilitate user access to informa tion. Relying on clustering techniques, both unsupervised and supervised, characterization algorithms compute "image content vectors" which categorize the features contained within an image. Based on results to date, a combination of probabilistic neural networks and back propagation-trained neural networks are best suited to the task of rapid, accurate pixel labeling. Because both of these techniques require the user to supply training sets of sample information, a photointerpretation tool is used to enable a user to identify, select, and label homogeneous regions within a multispectral image.

Advanced planning and scheduling

The planning/scheduling/dispatcher capability is based on a commercial planner product that NASA has enhanced to allow the user to visualize the schedule structure during plan execution. The system can actually dynamically reconfigure itself to make the best use of computing resources even though they are distributed and changing in availability. The "planning" subsystem generates plans for raw data capture, product generation, and response to user requests. These plans, generated in the form of data flow diagrams, are then provided to the "scheduling" subsystem, where resources are identified and a sequence of execution steps is defined. A "dispatcher" subsystem then initiates and monitors the defined processing steps.

User-friendly query interface

Data and information are valuable only if the user knows the data exists and has quick, effective access to those files that serve his/her interests. Therefore a query interface was developed to provide this capability in a convenient single-screen format. This graphical capability permits users to request data by location on the Earth's surface (by specifying

polygonal regions on a digital world map), by capture time, by data source, and by user -definable descriptions of image information content. In response to a user-submitted query, the interface returns low resolution "thumbnail" images that the user can browse. Selecting a thumbnail image initiates the display of a pull-down menu that identifies options for image copying or product generation.

Resource and algorithm registration

This feature officially registers the system computing resources and each process or algo rithm to be applied to data in the system. It allows the system curator to establish rules for the use of system resources and record these rules in the database along with the process algorithms. These rules include the conditions under which each algorithm is applied, the system resources needed to support each process, the process schedule, and the expected process inputs and outputs. Resources and algorithms are registered when resources are added or removed and when new processes and/or products are required of the system. The planning and scheduling function then uses this registration information to trigger the processes when all the preconditions to their activation are met.

Object-oriented database management

Unlike commercial data processing operations which are characterized by simple data types, transaction-oriented operations, and restrictive retrieval languages such as SQL, the management of geo-referenced data from satellites and other sources requires complex, flexible, and often application-dependent indexing methods for retrieving data in the form of images, video, and text. The RAC utilizes an object-oriented database management system to represent the remote serving domain. The system satisfies user queries by effi ciently searching a variety of data structures chosen to best capture the ways people re quest the data.

Sphere quadtrees: a data structure for global knowledge representation

The searching of large Earth satellite databases and the fusion of satellite data with multi -source correlative data are often hampered by the row-column schemes used to represent global geo-referenced data. Attempts to make digital flat maps from the sphere result either in large gaps, dislocations, or a lack of uniformity among some geometric properties of grid cells. NASA, however, uses a sphere quadtree structure to model a digital spherical image using small triangular picture elements called trixels. The sphere quadtree structure pro vides a means to locate data anywhere on the globe through a combination of several desirable properties:

- abstraction (which provides for the well-defined manipulation of topological objects over a digital sphere geometry)
- topological consistency (which enables efficient integer-based algorithms to deal with connectivity, distance, and neighborhood functions)
- rapid access to data
- variable resolution of data to use storage space efficiently
- representation of a region at multiple resolutions
- improved interactive browsing (through the elimination of breaks and tears that might occur in flat map structures)

Use of Commercial Products and Tools

Although a number of configurations are possible for the RAC, the following commercial products and tools were used in the working prototypes. The object-oriented database used in the RVC system is Objectstore from Object Design International. The various scripts and graphic user interfaces used to control the system are built in TCL and TK. CSH scripts are also used for certain tasks. Rogue Wave Tools (h++ for Objectstore) is used for some utility classes in the C++ code. Allegro Common Lisp is used as the basis for the Planner/Sched uler. Honeywell developed the scheduling program that serves as the basis for the Plan ner/Scheduler and it also runs in Lisp. QStar Hierarchical Storage Management software is used to manage the mass storage system. For the prototype RACs, the mass storage system consists of four 9-gigabyte drives and an Exabyte 11-tape stacker.

System applications

The modular RAC design allows system components to be distributed across widely sepa rated operational bases. Each of these remote systems can be linked to a central data ware house to enable analysts, forecasters, and scientists to query, monitor and visualize infor mation; perform multiple data analysis tasks; and generate tailored data or information products to meet local operational and decision making needs.

Related development

In order to establish a fundamental set of remote sensing capabilities to meet a variety of local information requirements, the RAC program is investigating a number of technologies that can enhance the information acquisition and management capabilities of the RAC. These enhancements include:

- a direct receive capability to acquire and process data from new instruments that transmit data directly to the ground at X-band frequencies
- a Low Cost Unmanned Aerial Vehicle capability to evaluate hyperspectral technologies and to develop a remote sensing platform capable of carrying instruments that can support environmental monitoring and ground truth data acquisition
- hyperspectral data analysis tools adapted to workstations to support RAC users as data from new hyperspectral instruments become available
- development of a 128-processor version of GSFC's Beowulf supercomputer workstation to provide an inexpensive high-performance computing capability for application in the RACs

- investigation into using Field Programmable Gate Array technologies as another approach to securing an inexpensive high-performance computing capability for the RACs

Conclusion

The ultimate goal of the RAC program is to establish a fundamental set of remote sensing technologies that can be assembled by a specific user community, at varying levels of aggregation, to meet the information needs of that community. A major objective is to identify a set of technologies that provides the required capabilities at minimum cost.

Although begun as a technological innovation for gathering, processing, storing, and retrieving data in massive distributed databases, the RAC program is expanding to encom pass associated technologies that ensure the user ready access to pertinent information, at an attractive cost/performance ratio.

The technologies under development and/or investigation as part of the RAC program are being developed to "plug and play" seamlessly as modules of a single system. The working hypothesis is that an RAC-based remote sensing data center will be comprised of an intelligent information management capability, 155 Mbps satellite direct readout, a capability for hyperspectral data acquisition and processing, a UAV-based ground truth acquisition capacity, and massively parallel computing.

This paper was originally presented at the annual Technology Transfer Exhibition, Tech2007. This exhibition provides a forum for showcasing advanced technology, launching products, and pursuing licensing agreements and partnerships with the nations high-tech leaders, in one place in one time.

Acknowledgements and References

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AWARDS

1997 Gordon Bell Prize Awarded to Donald Becker/CESDIS and Team

Donald J. Becker/Universities Space Research Association/Center of Excellence in Space Data and Information Sciences (CESDIS) was one of a team awarded the 1997 Gordon Bell Prize for Price /Performance "in recognition of their superior effort in practical parallel-processing research." The award was announced and presented at SC97, the premier conference in high performance comput ing and networking.

A Beowulf cluster of Pentium Pro's assembled a year earlier at SC96 achieved 2.1 Gigaflop/s (bil lions of floating point operations per second) on an n-body code, the equivalent of $50,000 per Gigaflop/s. The code simulates gravitational attraction among particles, such as dark matter in cosmology models. Beowulf is a Linux-based cluster of pc's linked with fast Ethernet. It was developed at NASA/Goddard Space Flight Center over the past four years by CESDIS. Goddard-devel oped software has enabled Beowulf-class clusters to be built at institutions worldwide.

Other award recipients are Michael S. Warren and M. Patrick Goda/Los Alamos National Labora tory; John K. Salmon and Thomas Sterling, California Institute of Technology; and Gregoire S. Winckelmans, Catholic University of Louvain, Belgium.

The Gordon Bell Prize was established to reward practical use of parallel processors by giving monetary awards for the best performance and best price/performance on an application, and for automatic compiler parallelization. The award is sponsored by the IEEE Computer Society and IEEE Computer magazine.

The Gordon Bell Prize winners presented talks on their award-winning work at SC97. ■

The goal of NASA's many outreach programs is to promote to the general public an understanding of how NASA makes significant contributions to American education systems and to institutions dedicated to improving science literacy. This newsletter provides one vehicle for reporting how applications and hardware used for space science and other NASA research and development can be adapted for use by teachers and their students and by non-NASA organizations.

NASA Launches Live Internet Webcasts Worldwide

John Bluck, Public Information Office, and Pat Kaspar, NASA Research and Education Network, Ames Research Center

Melding broadcasting with the Internet, Ames Research Center's (ARC) Quest Project recently initiated the Learning Technologies Channel (LTC), which transmits live audio and video through the "web" to a worldwide Internet audience. The Quest Project is managed by the NASA-wide Learning Technologies Project, which is part of NASA's Office of High Performance Computing and Communication. The purpose of the LTC is to connect teachers and students to NASA scientists and researchers via the Internet to brief them on NASA's work. It was first used last year to present virtual conferences as well as virtual instruction in telerobotics for 75 students across the Western Hemisphere.

The Learning Technologies Project is a NASA-wide initiative with the goal of delivering NASA mission content to classrooms across the nation through the use of leading-edge technologies. Research is conducted in areas related to emerging technologies, many of which are related to the Internet, and then where appropriate, these technologies are used to implement high-quality and affordable learning environments which connect US classrooms with NASA missions and researchers. LTC is ARC's portion of the LTP.

Quest Project is a service of NASA's Education Program. Quest's mission is to provide support and services for schools, teachers and students to fully utilize the Internet, and its underlying information technologies, as a basic tool for learning.

NASA is a key participant in the Federal HPCC Program. The primary purpose of NASA's HPCC Program is to extend US technological leadership in high-performance computing and communications for the benefit of NASA stakeholders: the US aeronautics, Earth and space sciences, and spaceborne research communities. As international competition intensifies and as scientists push back the frontiers of knowledge, leading-edge computational science is more important than ever.

How LTC works

The LTC is designed to serve schools with data services ranging from slow (14.4kbps) to fast (1.544 Mbps) It is broadcast from a small trailer studio at ARC that sends live video and audio to an ARC ground station where it is encoded in RealAudio, RealVideo, and CUSeeMe and shipped out via the Internet to schools across the nation. Andrea McCurdy, LTC manager, explained that the main focus of the channel is to provide teacher training to educators where they are located.

"Many educators teach at rural schools that are just now connecting to the Internet," said McCurdy. "We also do all kinds of things that are fun for kids and the general public."

The Internet channel enables users to "feel" that they are part of each event by receiving information seamlessly, through use of graphics, audio, video and transcriptions of the audio. Students and teachers view digitized video and audio from the LTC. Chat windows on their computer screens permit students to submit questions that are answered during the webcasts. For some programs, a text transcription is generated to allow users with slow data services to participate. Web archives provide additional information.

"Our webcast events are not just old-style broadcast, but also are interactive mainly through Internet computer chat sessions," said Marc Siegel, Sterling Software, Quest project manager . "The new service works best for those with fast computers and fast Internet connections."

The programs

One of the first programs included a broadcast of live sound from a submarine that was exploring the ocean floor at a depth of 750 ft. - where human beings have never been before. Near Channel Islands National Park, off the southern

California coast, a ranger gave her first-hand account of what she saw from the submarine. From around the world, people listened to the submarine webcast while researchers tried to locate white abalone in the Pacific Ocean. Many student questions were answered during a concurrent Internet "chat session."

On NetDay, October 25, Dysart, Iowa, students were able to communicate with Mars researcher Robert Haberle at ARC. This demonstration was the result of an intense effort by the LTP staff to respond to a last-minute request from the Office of Vice President Gore to do a technology demonstration at the school for NetDay. The Dysart school had no network and only two 28.8 kbps modems, although family and students had installed cable for NetDay.

Credit: Left-to-right - ARC's Learning Technology Project Manager Mark Leon, Justin Messer, and Vice President Al Gore participate in Net Day on Wednesday October 25th. Leon explains to Gore how NASA will help meet the Vice President's goal to enable all of the nation's school systems online. Photo by Greg Reese.

"NASA rolled in like an angel from above and brought us technology we hadn't even imagined," said Greg Reese,Technology Director of the Union Community School District in Dysart.

In addition to the webcasts for students, an on-line, 10-part course for teachers, began in February, 98. The course, "Teach with the Internet," is offered by San Francisco State University.

"The Learning Technologies Channel lets educators and the general public participate in courses, workshops, seminars and other events that might otherwise be unavailable to them without leaving their schools or homes," said Karen Traicoff, the NASA official in charge of the Quest Project.

Learn more about the Learning Technologies Channel <http://quest.arc.nasa.gov/ltc/>. ■

NASA's wealth of technology is being re-used in the fields of medicine, industry, and education and by the military to develop products and processes that benefit many sectors of our society. Spinoff applications from NASA's research and development programs are our dividends on the national investment in aerospace.

NASA Aids Fight Against Cancer

NASA space-based research is revolutionizing ways to diagnose and treat breast and ovarian cancer, leading causes of death among women today, and cancerous brain tumors in children. Robotics, high speed networking, virtual reality, three dimensional (3D) imaging technologies, and photodynamic therapy, benefits of NASA's investigations into the universe, are being implemented in the medical arena.

Using imaging technology

Mammograms are used for initial screening for breast cancer. If a suspicious lump is detected, a follow-up Magnetic Resonance Imaging (MRI) technology, using contrast medium, can be conducted. The medium is injected into the patient's blood stream and rapidly concentrates in the tumor, which shows in the scan as a bright area. Digital breast imaging was developed by adapting the same kind of silicon chips used in the Hubble Space Telescope. The chips were adapted to detect tiny spots in breast tissue. Doctors are then able to analyze the tissue using needles rather than painful surgery, with significant savings in time and cost.

Even with this technique, it is hard to see where the tumor begins and ends, according to Dr. Ross, director of Ames Research Center's (ARC) Biocomputation Center. The Center, which uses computer technology to improve medical practices, is currently developing a technique to produce an entire image of the breast using 3D imaging - a technique to more accurately detect tumors.

In November at the Radiological Society of North America Conference, the Center displayed 3D images made from a series of scans of a breast and tumor. Each high fidelity 3D picture is a "reconstruction," a computerized visual model of affected breasts with tumors that physicians wearing 3D glasses can see from all angles on a computer monitor. According to Ross these reconstructions are highly accurate 3D. In the new reconstruction technique, a series of (MRI) breast scans are combined to make a 3D image using Reconstruction of Serial Sections (ROSS) software that was developed in the Center. The method eliminates "noise," or interference, seen in more common renderings of breast tissues done in many clinics.

"Once this (reconstruction) technique is fully developed, we think physicians will be able to visualize the borders of tumors more clearly," stated Dr. Ross. "For this initial reconstruction, we combined features of the ROSS software we have been using with another version we use for Computed Axial Tomography (CAT) scans. Eventually, a special version of the software will be developed for MRI. In the meantime, we have demonstrated that high fidelity, 3D reconstructions can be made from typical MRI breast scans."

Using sound

In the future the Center intends to work with sonograms, a scan that uses sound to visualize objects inside bodies. Dr Ross explained that the Center wants to reduce noise that comes from multiple, echo-like reflections of sound coming from tissues. The technology developed for Mars Pathfinder is being modified to make 3D models of breast tissue. The imaging device then combines ultrasound technology with advanced computing to discern cancerous tissue from healthy tissue by comparing changes in shape and by analzing the ultasound signal.

"Borders of objects can be difficult to define because echoes bounce, and can interfere with one another," Dr. Ross explained.

Using virtual reality

The Biocomputation Center will become part of a larger National Biocomputation Center soon to be established by NASA and Stanford University. The NASA-Stanford center will be a national resource to further the use of virtual reality (VR) in medicine. VR, a computer-created environment that simulates a real-life situation, will allow surgeons to rehearse complex procedures before an operation. In addition, the team expects virtual reality will be a powerful teaching tool for medical students. A digital library of computerized "virtual patients" will be created that physicians can use to share information about uncommon procedures, according to researchers.

In work related to the breast tumor 3D imaging program, the NASA-Stanford biocomputation team is working on VR computer tools to aid in complex facial reconstructive surgery where surgeons can use a big-screen workbench, special gloves, computer tracking wands, and software to manipulate a 3D computer image of the patient. The surgeon can work

on the virtual reality image and replace the soft tissues to see what the patient may look like after facial reconstruction. Another VR application is working with mastectomy patients needing breast reconstruction, and with children who need reconstructive surgery to correct deformities of the head and face. Eventually the system could be used in other medical specialties or surgical procedures.

Development of the breast tumor 3D visualization software follows an agreement that enlists NASA technologies to fight breast cancer and other women's illnesses. The agreement was signed in October in Washington, DC, by representatives of NASA and the Department of Health and Human Services. Major areas of concern are cancer, reproductive health, pregnancy, osteoporosis, and education.

Using light emitting diodes

Photodynamic therapy, a technique using tiny pinhead-size light emitting diodes (LEDs), is being used to activate light-sensitive, tumor-treating drugs. The LEDs were developed by NASA for use on the Space Shuttle in plant growth experiments. Studies indicate that when special tumor-fighting drugs are illuminated with LEDs, the tumors can be more effectively destroyed than with conventional surgery. The light source, consisting of 144 of the tiny diodes, is compact - the size of a small human finger about one-half-inch in diameter - and mechanically more reliable than lasers and other light sources used to treat cancer. The entire light source and cooling system is only the size of a medium suitcase.

Dr. Harry Whelan of the Medical College of Milwaukee, Wisconsin, has obtained Food and Drug Administration approval to use the LED probe for the treatment of children's brain tumors on a trial basis. Dr. Whelan's therapy involves injecting the patient's bloodstream with a drug called Photofrin II. Photofrin II attaches to the unwanted tissues and permeates into them, leaving the surrounding tissues unaffected. Dr. Whelan then places the new solid-state LED probe near the affected tissue to illuminate the tumor and activate the Photofrin II drug. Once activated by the light, the drug destroys the tumor's cells, leaving the normal brain tissues virtually untouched.

"This new probe," said Dr. Whelan, "illuminates through all nearby tissues. We've used lasers too, but they are often unreliable and limited in color spectrum. Lasers also are very expensive and lose power in their fiberoptic cables."

The feasibility of using LEDs in cancer treatment was demonstrated through a NASA Small Business Innovation Research contract managed by the Technology Transfer Office at the Marshall Space Flight Center. The small business, Quantum Devices, Inc., of Banreveld, Wisconsin, developed the LEDs as a light source for a chamber used by NASA to conduct plant research in space. These LEDs now form the tip of a new nine-inch neural probe.

"We're very happy to be a part of this innovative procedure," said Rose Allen, manager of the Space Product Development Office at MSFC. "It is exciting to see how NASA's commercial space research results in benefits on Earth. Who would have thought that experiments searching for ways to improve agricultural products would lead to a medical procedure that could save children's lives?"

"The LED technology developed by NASA offers new hope to children with cancer," Dr. Whelan said. "Every one of our cases will be a critical case with no hopeful alternatives. We think this new probe will help give children with tumors a chance to live healthy, happy lives."

After Whelan concludes the FDA clinical trials, he anticipates full approval of what soon could be the operating technique of the future. Further research combining LEDs and new promising drugs is showing the possibilities of deeper tumor penetration with the probe, faster reaction times and shortened patient sensitivities to sunlight.

LED's low-energy technology flew on the second United States Microgravity Laboratory Spacelab mission in October 1995, as part of the Astroculture Plant Growth Facility. That experiment was led by Dr. Raymond Bula of the Wisconsin Center for Space Automation and Robotics, a NASA Commercial Space Center. Commercial Space Centers, supported by NASA, pursue opportunities for continued growth of US industry through the use of space.

"NASA has played a number of important roles," Dr. Whelan said. "NASA has funded the development of these LEDs for space research over the years," he added. "If it wasn't for the pre-existence of all that technology, it wouldn't have been possible for us to walk right in and use it to treat cancer."

Material excerpted from several NASA press releases. ■